ANCILLARY SERVICES AND BULK-POWER RELIABILITY

A Position Paper of the
Electric-System Reliability Task Force
Secretary of Energy Advisory Board
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1. BACKGROUND

This paper provides background on ancillary services[1] and Task Force recommendations to ensure that these services are available, produced, and managed so as to maintain bulk-power reliability. Ancillary services are critical to the reliable operation of the bulk-power system. They are necessary to assure stability of the grid and to prevent cascading outages in the event of an unplanned outage of a generating unit or transmission facility. Some ancillary services (e.g. system blackstart capability) are necessary to recover from an outage.

Ancillary services are those functions performed by the equipment and people that generate, control, and transmit electricity in support of the basic services of generating capacity, energy supply, and power delivery. Historically, these services have been provided by vertically integrated utilities as part of their bundled electricity product. Increasingly, as the industry is being restructured, they are being supplied as separate services in a system that includes unbundled generation, transmission, and system control. The Federal Energy Regulatory Commission (FERC) defined such services as those "necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system." As discussed below, these ancillary services are only rarely optional.

Twelve Key Services

FERC's April 1996 Order 888 specifies six services that transmission providers are required to offer (Table 1). The Interconnected Operations Services Working Group (facilitated by the North American Electric Reliability Council and the Electric Power Research Institute) identified an additional six services, some of which are essential for reliability (e.g., system black start and

1. Readers interested in additional details on the definitions, metrics, and requirements for these services should see: E. Hirst and B. Kirby 1998, *Unbundling Generation and Transmission Services for Competitive Electricity Markets: Examining Ancillary Services*, NRRI 98-05, prepared for the National Regulatory Research Institute, Columbus, OH, January; and Interconnected Operations Services Working Group 1997, *Defining Interconnected Operations Services Under Open Access*, EPRI TR-108097, Electric Power Research Institute, Palo Alto, CA, May.

network stability services).[2] FERC discussed some of these additional services in Order 888 but did not require transmission providers to offer them. As the electricity industry evolves, further unbundling or rebundling of services may be desirable.

As shown in Table 1, most ancillary services are provided by generating units, some are provided by transmission-system equipment, and some are provided by both generators and transmission equipment. Almost all services must be under the control of the system operator. Although FERC requires transmission providers to offer six services to transmission customers, five of the six are produced by generating units not by transmission equipment.

Functions

Of the 12 services shown in Table 1, six are required for normal operation of bulk-power systems, including system control, voltage control, regulation, energy imbalance, load following, and loss replacement. These services ensure that voltages and equipment loadings are maintained within appropriate limits and that the necessary generation/load (production/consumption) balance is maintained at all times.

Five services are used to prevent minor problems from cascading into major outages. These services include spinning reserve, supplemental reserve, and network stability as well as system control and voltage control (both of which are necessary for normal operations).

Finally, eight services are required to safely and promptly restore systems after a major disturbance occurs. These services are system blackstart as well as the previously cited services of system control, voltage control, network stability, regulation, the two operating reserves, and load following.

Clearly, these ancillary services perform essential functions in maintaining the integrity of the transmission system, in preventing small problems from becoming major problems, and in resolving those rare, but serious major problems. Indeed, only three services serve no reliability function: energy imbalance, backup supply, and dynamic scheduling. These three services are needed only for commercial purposes.

2. Regardless of the number, names, and definitions of these services, the physics of electric-power networks require that they be provided at the right times and places and in the correct quantities.

Table 1. Key ancillary services and their definitions

Service	Description	Time scale
Services FERC requires transmission providers to offer and customers to take from the transmission provider		
System control	The control-area operator functions that schedule generation and transactions before the fact and that control some generation in real-time to maintain generation/load balance; Interconnected Operations Services Working Group definition more restricted, with a focus on reliability, not commercial, activities, including generation/load balance, transmission security, and emergency preparedness	Seconds to hours
Reactive supply and voltage control from generation	The injection or absorption of reactive power from generators to maintain transmission-system voltages within required ranges	Seconds to hours
Services FERC requires transmission providers to offer but which customers can take from the transmission provider, buy from third parties, or self-provide [a]		
Regulation	The use of generation equipped with governors and automatic-generation control (AGC) to maintain minute-to-minute generation/load balance within the control area to meet NERC control-performance standards	~1 minute
Operating reserve - spinning	The provision of generating capacity (usually with governors and AGC) that is synchronized to the grid and is unloaded that can respond immediately to correct for generation/load imbalances caused by generation and transmission outages and that is fully available within 10 minutes	Seconds to <10 minutes
Operating reserve - supplemental	The provision of generating capacity and curtailable load used to correct for generation/load imbalances caused by generation and transmission outages and that is fully available within 10 minutes[b]	<10 minutes
Energy imbalance	The use of generation to correct for hourly mismatches between actual and scheduled transactions between suppliers and their customers	Hourly
Services FERC does not require transmission providers to offer		
Load following	The use of generation to meet the hour-to-hour and daily variations in system load	10 minutes to hours
Backup supply	Generating capacity that can be made fully available within one hour; used to back up operating reserves and for commercial purposes	30 to 60 minutes
Real-power-loss replacement	The use of generation to compensate for the transmission-system losses from generators to loads	seconds to hour
Dynamic scheduling	Real-time metering, telemetering, and computer software and hardware to electronically transfer some or all of a generator's output or a customer's load from one control area to another	Seconds
System-black-start capability	The ability of a generating unit to go from a shutdown condition to an operating condition without assistance from the electrical grid and then to energize the grid to help other units start after a blackout occurs	When outages occur
Network-stability services	Maintenance and use of special equipment (e.g., power-system stabilizers and dynamic-braking resistors) to maintain a secure transmission system	Cycles

[a] These four services are required only to serve load within the control area, not for wheeling through.
[b] Unlike spinning reserve, supplemental reserve is not required to begin responding immediately.

Monopoly and Market Approaches to Pricing and Provision

Because most of these 12 services are provided by generators, it should be possible to create competitive markets for them. Such services include regulation, load following, spinning reserve, supplemental reserve, backup supply, energy imbalance, and loss replacement. Markets for these seven services are likely to be competitive where the markets for the basic energy commodity are workably competitive. In such cases, markets, rather than government regulators, will determine the suppliers of and set the prices for these services.

It may be possible to establish competitive markets for three additional services, voltage control, blackstart capability, and network stability. The opportunities to create markets for these three services may be limited because of the locational requirements of these services. For example, the injection and absorption of reactive power must occur close to where voltages must be maintained within required limits. In other words, transmission grids can transport reactive power over much shorter distances than they can transport real power.

Because generators provide both the energy commodity and several ancillary services, there will be strong interactions between and among the markets for energy and these services. To ensure that reliability can be maintained, the rules governing provision of and payment for ancillary services must discourage gaming. Failure to establish suitable structures and rules for these markets will complicate the provision of ancillary services and therefore electricity markets.

The cost-causation factors used to price these services to customers may vary from service to service and with time (e.g. from hour to hour). As examples, these costs might be related to and therefore collected on the basis of energy consumption, peak demand, short-term (minute-to-minute) volatility of load, and so on.

Finally, creation of competitive markets will offer opportunities for greater customer participation in these markets. Historically, customer options were limited to a few choices, such as interruptible rates and direct load control. Greater use of real-time pricing plus customer bids to supply operating reserves may increase system reliability at lower costs than would occur through reliance on traditional supply options alone.

System Operator Role

Regardless of whether markets or regulators determine the prices of some ancillary services, the system operator will remain the primary authority on how much of each service is required each hour and, for some services, the locations at which these services must be provided to the grid.[3]

3. The control-area operator might be a traditional vertically integrated utility, an independent system operator (ISO), or some other entity. To the extent that the system operator is independent of commercial interests, its decisions and actions are more likely to be trusted and honored than if the system operator has commercial interests in electricity markets.

The system operator will also determine how to select service providers, e.g., through competitive bidding, long-term bilateral contracts, or FERC-approved tariffs. The system operator, consistent with national reliability requirements, will establish (1) a priori (e.g., day ahead) requirements for each service and (2) real-time management of the resources that provide these services. Clear specifications will ensure that service providers and consumers know what to expect, how performance will be measured, and who will pay whom for what.

By definition, the system operator is the only entity that can provide the system control and scheduling service. However, almost by definition, the system operator cannot provide any of the other services. To the extent that the system operator is *independent* of the owners of generation and transmission, it will not be able to physically provide these ancillary services.

However, the system operator may need to control the provision of many of these services. The role of the system operator is crucial for three reasons. First, the system operator is the only entity that has enough real-time information to know how much of each service is required and any locational restrictions on the provision of these services. Second, it is much more cost effective to provide many of the services (e.g., regulation and operating reserves) for the aggregate load than for each load separately. Third, it would be very difficult to provide some services, such as system control and voltage control, to individual customers. Indeed, it is desirable to provide the services to individual customers for only a few services, including backup supply, energy imbalance, dynamic scheduling, and perhaps load following and losses.

With respect to system services, the system operator—and only the system operator—knows what the regulation requirements are for the control area from second to second. The operator's knowledge of area-control error (ACE), calculated every two to four seconds, is the basis for its decisions on whether and how to use the regulating margin at its disposal. Thus, although the generators that provide this service may be neither owned nor operated by the system operator, their provision of the regulation service is controlled by the AGC signals that the system operator sends to each generating unit that is providing the service.

In a similar fashion, only the system operator, based on its knowledge of power flows and possible contingencies, can set the voltage schedules and reactive-power reserves throughout the transmission grid. Therefore, voltage schedules and the resulting reactive-power injection and absorption must be under the control of the system operator.

Analogous situations apply to the operating-reserve services, energy imbalance, black-start capability, and network-stability services. For all of these services, the system operator is the only entity with sufficient and timely information to decide how much of each service is required. In addition, system provision of the service, rather than customer provision, provides economies of scale. That is, fewer resources are required to provide a given level of service to an aggregation of loads than to the sum of the services provided to individual loads.

The operator does not need to control the provision of backup supply or dynamic scheduling. However, it needs up-to-date (i.e., once every several seconds for dynamic scheduling) information on the status of these services and their provision. This information requirement is a consequence of the system operator's responsibility to maintain generation/load balance within the control area.

The operator does need to control the real-time provision of losses. But the operator does not need to choose the generators that provide for loss compensation.

2. TASK FORCE RECOMMENDATIONS

Because ancillary services are integral to bulk-power reliability, the Task Force on Electric-System Reliability offers the following suggestions:

1) The Self-Regulating Reliability Organization (SRRO), subject to FERC jurisdiction, should develop and implement clear and consistent national definitions of ancillary services. These definitions should include methods to measure the capability and the delivery of each service as well as penalties for noncompliance with these performance metrics. These definitions should be sufficiently flexible to encourage innovative ways to provide the service (e.g., automatic control of some customer loads could serve as alternatives to generation for spinning reserve). Periodically, the FERC should consider additions, deletions, and modifications to the six ancillary services included in Order 888. This expansion could apply to services such as system blackstart, network stability, load following, and perhaps others.

2) FERC and the system operators should promote the creation of competitive markets for ancillary services wherever feasible. Competitive markets offer the possibility of increased reliability at lower cost, as well as fewer regulatory controversies over embedded-cost pricing. When it is demonstrated that competitive markets exist, FERC's price-setting role could be minimal. Where locational requirements are strict and ancillary service providers are limited, competitive markets may not be feasible. In such cases, FERC should continue to regulate the provision and pricing of these services.

3) FERC and the system operators should ensure that all bulk-power market participants provide (or secure from third parties) their fair share of ancillary services, especially those required for bulk-power reliability. Where costs can be assigned to specific customers (e.g., for backup supply or dynamic scheduling), those customers should pay the full costs.

4) FERC and the system operators should ensure that the providers of ancillary services have opportunity to receive fair compensation for the prudently incurred costs to produce those services not provided through competitive markets. FERC's role in setting prices will

likely be a function of the independence of the system operator from commercial interests and the strengths of competitive markets for these ancillary services. Where competitive markets exist, FERC jurisdictional utilities should no longer be obligated to offer these services at embedded-cost prices.

5) FERC and the SRRO should ensure that system operators have sufficient authority to compel generation and transmission owners to supply (and customers to pay for) the amounts and characteristics of each service determined by the system operators to be required for reliability and to support commercial transactions. The system operator must be the final authority on how much of a service is required and, in some cases, the locations at which that service must be provided to the grid. The system operator need have no authority over the prices of most services. To the extent that system operators have no commercial interests in electricity markets, FERC's oversight could likely be reduced.

3. CONCLUSIONS

The U.S. electricity industry is currently in the midst of a major transition from one dominated by large vertically integrated utilities that sell a bundled electricity service to retail-monopoly-franchise customers to one that is dominated by competitive generating firms and regulated transmission and distribution entities. Because the ancillary services discussed here are essential for maintaining bulk-power reliability, the DOE Task Force is concerned that their availability, production, and deployment be maintained. Substantial progress has been made during the past few years to identify and define these critical services. However, much remains to be done to develop a clear understanding and workable definitions of these services, as well as appropriate pricing rules for them.